Eleventh Quarterly Report

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Project Title: Effect of Concentration and Temperature of Ethanol in Fuel Blends on Microbial and Stress Corrosion Cracking of High-Strength Steels

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For quarterly period ending: *March 14. 2010,*

TECHNICAL STATUS

Technical efforts for the 11th quarter have included field sampling of fuels from ethanol fuel blend (EFB) infrastructure, 16S rRNA gene sequencing, laboratory cultivation experiments, MSBT experiments, immersion testing, electrochemical experiments, and FCGR testing.

Technical Status Overview

Field Assessment and Microbiological Characterization:

- Collected samples from ethanol containment tanks and E10 fuel tanks for microbial characterization and chemical analyses.
- Identified microbes in E10 fuels with 16S rRNA gene sequencing.
- Began the process of field-testing with steel coupons in ethanol containment tanks.
- Prepared samples for a high-throughput DNA sequencing technique that will provide greater insight into the types of microbes present in ethanol fuel blend environments.
- Maintained microbial cultures for mechanical testing of steels in ethanolic environments.

Electrochemical Corrosion Testing:

- OCP and EIS measurements have been used to characterize corrosion parameters for APB on X70 and X52 in growth media containing 5 pct. ethanol as a carbon source
- OCP and EIS measurements have been used to characterize corrosion parameters for SRB on X70 and X52 in growth media containing 2 pct. ethanol as a carbon source

Multi-Specimen Bend Testing:

- Four-point bend testing was conducted to evaluate the effect of elastic cyclic loading on corrosion and crack initiation on smooth rectangular coupons in seawater
- Four-point bend testing was conducted to evaluate the effect of elastic cyclic loading on corrosion and crack initiation of smooth rectangular A36 coupons in APB media with 5 pct. ethanol added as a carbon source

Fatigue Crack Growth Rate Testing:

- Baseline fatigue crack growth rates were determined in air for A36, X52, and X70 steels in the Paris Law regime. X70 had the lowest crack growth rates and A36 and X52 had similar crack growth rates.
- Fatigue experiments of the pipeline steels in simulated fuel grade ethanol are underway to serve as a baseline solution before further testing is performed in the presence of

microbes in ethanol solutions. The experimental system for fatigue in ethanol fuels functions as intended.

- Fatigue behavior of X70 in simulated fuel grade ethanol was determined in the Paris Law regime, and crack growth rates were determined to be significantly higher than in air in the ΔK range of 20 to 65 MPa $\sqrt{m}$. Paris law coefficients were also found.
- Accelerated crack growth rates in simulated fuel grade ethanol may be attributed to corrosion fatigue and stress corrosion fatigue mechanisms although characterization work is required on fractured specimens to completely explain the accelerated behavior. This evaluation is currently underway.
- Corrosion and stress corrosion fatigue processes are highly dependent on loading frequency; however, a frequency of 0.1Hz provides a good compromise between maintaining short test times and adequately capturing crack growth behavior in the presence of corrosion solution. A testing frequency of 0.1Hz will be used for all subsequent studies where microbes are present.
- A safety review has been completed at NIST and the facility is ready to test with microbes.